SOIL CONSERVATION

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THE practical soil conservationist nowadays talks with a stem of timothy hay in his mouth.

HE KNOWS that grass, shrubs, vines, trees, roots, ground litter of leaves and stems, crop residues and organic matter accumulated within the body of the soil are Nature's own guardians of the land and effective weapons of land defense at the service of every farmer. If a farmer is to lick erosion, he must cloak his fields or portions of them with vegetation and work into his soil spongy, absorptive vegetable matter to bind the soil and to hold needed water. That single statement just about sums up the challenge and the answer to accelerated soil erosion on millions of acres.

THE Soil Conservation Service has an immediate and continued concern with the utilization of materials and weapons at hand, with the reestablishment of suitable cover on denuded areas, with the discovery and development of plants of superior erosion-resisting and economic qualities, with practices that will add to the value of existing pastures, and with cultivation for profits rather than losses.

ROTATION is no new discovery; it has been preached and practiced by generations of intelligent husbandmen. Field production, pasture and range management, fences, woodlots, stock ponds—chapters old and shelf-worn—have merely been revised or given accent in the light of accruing necessity. Today, for example, we curve the fields and the rows, plant in strips, aim at cloddy cultivation, test buffer strips and meadow strips, slow rather than hasten run-off, measure the slopes and appraise the erodibility of soils. We find it just as scientific to be practical as it is practical to be scientific.

A READING of the contents of this issue of SOIL CONSERVATION reveals how fundamental is vegetation in the program of the Service. Erosion engineering itself leans far more heavily on vegetative materials than on the more spectacular masonry. It recognizes that land values and special land conditions largely govern the use of mechanical structures, and that the farmer's skill and convenience give preference to sod, shrubs, vines, and trees.

THIS, of course, is not all of the program that must be applied to thousands of farms—to most farms. It is, nevertheless, a tremendously important part of the integrated plan adopted by the Soil Conservation Service to control erosion and conserve water. This plan calls for the treatment of the different kinds of land that make up a field or a farm, according to the needs and adaptabilities of each field or parcel of land. We cannot plant all of our cotton fields to grass, or all of our wheat fields to trees. Accordingly, it is necessary to compromise with Nature's plan to some extent; and, in addition to making use of vegetative measures of control, we must plow on the contour, build diversion ditches, terraces, dikes and dams where they are needed or where they assist other control measures required to meet the complex conditions existing over the agricultural domain of the Nation.

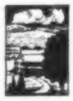
AS I TRAVEL agricultural America, I am gratified at the comparative absence of grandiose ideas on how to conserve soil and water. On projects, on cooperating farms, on adjacent farms, the trend is toward grass, toward soil-building crops, toward contour cultivation, toward a scheme of soil defense and water conservation that may be embraced readily by the average producer and at the same time permit him to live off the land.

A Foreword to This Issue

By the Chief of the Soil Conservation Service

ECOLOGICAL PRINCIPLES

W·C·Lowdermilk[1] offers basic approach to sustained land use



THE research program is directed toward determining the character of soil erosion and the methods of integrated action for its control. The steps include: comprehensive Nation-wide land-use planning; general application of emergency measures to arrest the rate of soil-resource loss, including structural work and quick revegetation; permanent soil-conserving agriculture based upon the principles of applied ecology.

The ecological approach is based upon realization that accelerated soil wastage does not occur under undisturbed conditions, and that natural processes in the past have served to develop a high order of soil fertility. We have seen the havoc wrought by man in changing natural conditions without due precautions against the accelerated action of wind and water. We therefore must aim at the use of Nature's constructive methods both in overcoming the destructive forces and in providing our needs from the soil. This calls for integrated land-use planning and management, and appears to be leading toward a new type of applied science which, lacking a better name, may be termed "vegetative engineering" or "ecological engineering."

The fundamental considerations in the ecological approach to erosion control are: (*a*) To restrict cultivation as far as practicable to flat lands and gentler sloping lands; (*b*) to conserve fertility of soil under tillage by technically adequate cultural methods; (*c*) to supplement the products of tillage by products that may be profitably produced by permanent vegetative covers managed and directed through controlled ecological successions.

The soundness and wisdom of the ecological approach to sustained land use is found in those countries where the pressing needs of human populations, combined with technological progress, have brought about more intelligent methods of land management. The Japanese have reclaimed the formerly barren slopes of their mountain sides in an effort to attain economic freedom through requisite wood products. Their method has been remarkably simplified through study and experience. It is based upon planting a few species of grasses and shrubs to form the initial temporary cover which is rapidly changed over into a permanently integrated forest cover.

In the United States, except for advances made in applied forestry science, we have made use of the ecological measures chiefly by leaving to nature the process of rebuilding soils after they have been depleted of fertility and eroded to such an extent that tillage became unprofitable. As the development of our country moved westward, it was easier to clear new land than to repair worn-out soils. Today we must regret some of our extravagance, revise our system of land use and rebuild many of our soils in accordance with nature's soil-conserving principles.

Present research deals chiefly with the character of accelerated erosion and with the economically feasible emergency steps that can be employed quickly to arrest damage. This is necessary in order to set the stage for the permanent methods of erosion-control farming and ecological engineering that must follow.

The heart of this principle lies in the parallel courses of water conservation and regulation on the one hand; and in better managed vegetation on the other. Over much of the area requiring soil protection there is normally a shortage of water during the growth season, this, in turn, lessens the opportunity for producing an abundance of vegetative cover. The hazards of wind and water erosion have accordingly a tendency to occur alternately.

Present efforts deal with structures, processes, and treatments calculated to regulate and conserve water to the best advantage of plant growth. Contour structures and devices to prevent run-off, vegetative and mechanical means for utilizing the porosity of the soil, and various forms of strip cropping are all useful in regulating run-off of surface water and in facilitating water absorption by the soil. Where there is an excess of water during certain seasons, our effort is to hold it where it falls for future needs. The water problems in their many aspects, therefore, constitute an important part of the integrated land management that is basic to a permanent agriculture.

The other primary factor in this broad picture is plant life itself. Past effort in erosion control by vegetative means often failed because it was based

(*Continued on p. 59*)

[1] Chief, Soil Conservation Research, Soil Conservation Service, Washington, D. C.

FLOOD CONTROL

Supplemental value of vegetative cover stressed *by* A·L·Patrick[1]

EXPERIMENTS of recent years have demonstrated the value of vegetative cover in reducing run-off and the part this plays in a flood-control program. Today its use is receiving more consideration by flood-control workers, including engineers, foresters, agronomists, and others. It is not to be inferred that vegetative cover alone is sufficient to eliminate floods. It must be supplemental to other practices applied on the land, as well as to the various types of flood-control structures commonly used along trunk streams. The real value of vegetative cover as a flood-control measure is brought about by increased infiltration of water into the soil and a greater utilization of the soil's storage capacity.

The ways in which vegetation assists infiltration are many and varied. Among the most important should be listed the improvement of structure, or particle arrangement, in fine-textured soils. Small live roots and finely decomposed organic material help to bring about a rearrangement of these particles so that they gather together in small clumps or little aggregates between which the openings are fairly large. In such a condition, clays and loams tend to act much like sands in their ability to absorb water rapidly Openings made by worms, insects, and decayed roots form channels down which water runs by gravitational action very rapidly.

It is essential, if water is to percolate into the soil at the maximum rate, that all of the natural soil openings be kept open. In reality, they constitute small channels running to considerable depths below the surface. None of the soil openings are very large in diameter, but they make up in quantity for the lack of size. They are easily clogged by muddy water, and when clogged rainwater runs off and over the surface instead of into the soil. Soil protected by litter (leaves, twigs, humus, etc.) or dense sods contain openings which are seldom clogged. The raindrop does not stir up fine particles to be washed into the minute channels; instead it is divided into a fine spray of clear water which percolates rapidly into the soil. The total or partial destruction of these soil protective materials by improper management of forest or grass lands, or by cultivation, results in flash run-off and loss of soil by erosion.

[1] Chief, Watershed and Conservation Survey Division, Soil Conservation Service, Washington, D. C.

The soil mass is divided into solid matter and pore space. Pore space is the portion of a volume of soil which is occupied by water or air. Largely because of the tendency to granulate, fine soils have a large amount of pore space; and the coarser the soil, the smaller is the amount of internal space. The following table taken from King illustrates the extent of pore space in relation to soil texture.

	Percentage of pore space
Sandy soil	32.49
Loam	34.49
Heavy loam	44.15
Loamy clay soil	45.32
Clayey loam	47.10
Clay	48.00
Very fine clay	52.94

The above table shows that the space in soil which may be occupied by water varies from one-third to over one-half of the actual volume. Middleton has interpreted pore space in terms of inches of rainfall down to a depth of 3 feet for three common midwestern soils.

Porosity of 3 representative soils [1]

Soil type and location	Depth of sample	Porosity	Calculated maximum possible water storage of surface 3 feet of soil [2]
	Inches	*Percent by volume*	*Inches*
Vernon fine sandy loam, Guthrie, Okla.	([3])	43.3	14.4
	2½	41.5	
	8	41.7	
	22	39.4	
	38	40.2	
Muskingum silt loam, Zanesville, Ohio.	([3])	48.1	16.2
	3½	45.1	
	9	47.8	
	17	45.5	
	32	31.3	
	54	32.7	
Marshall silt loam, Clarinda, Iowa	([3])	55.9	20.7
	6½	56.4	
	18½	60.3	
	32½	58.7	

[1] Middleton, H. E., Slater, C. S., and Byers, H. G. The Physical and Chemical Characteristics of the Soils from the Erosion Experiment Stations—Second Report. U. S. Dept. Agr. Tech. Bull. 430, 1934.

[2] The figures under this heading were calculated by Dr. Middleton but not included in the publication.

[3] Surface.

Newly contour-furrowed pasture, Beaver Run (Pa.) project.

The same furrowed field following a rain.

Assuming that this internal space continues at about this same ratio to solid matter as depth increases until solid rock is encountered, then one will begin to visualize the vast water-storage capacity that exists in the soil—a capacity so great as to be capable of accommodating all the water that falls for a considerable period of time. At Zanesville, Ohio, last January, after the storm which produced the floods on the Ohio River watershed had been in progress several days, the soil gave every appearance of being saturated. Nevertheless, soil covered with good grass sod continued to absorb water at the end of the storm period at about the same rate as at the beginning of the storm. This indicates that the soil was not saturated, but rather that there was a continuous downward movement of water into the lower soil strata and eventually into the ground water supply.

A potentially large soil reservoir exists; yet water running off the surface of the land carries with it rich life-sustaining topsoil, resulting in swollen streams, shoaling of channels, floods, and destruction. The existence of an unsaturated internal water reservoir does not imply that it will be utilized. The problem facing those interested in watershed retardation of precipitation is how to make the greatest possible use of this potential storage capacity.

It is true that rain water will run off sloping land covered with dense sods or virgin forests if the ground is frozen, if the rock is close to the surface, or if an extremely indurated layer occurs close to the surface. On the other hand, ground covered with dense sods or deep leaf litter are less likely to be frozen than is unprotected land. Hardpan layers are not commonly found on sloping land, and bed rock seldom occurs over extensive areas close to the surface. Many experiments show that grass and trees are Nature's means of protecting soil from washing and excessive run-off. Federal experiment stations are at present carrying on approximately 500 individual field and laboratory studies involving the effectiveness of vegetative cover and land use in reducing run-off and erosion. Many of these studies involve precise measurement of rate and quantity of precipitation, and the resulting run-off and erosion in carefully controlled areas varies from small plats of watersheds up to 30,000 acres. Data are being accumulated from every

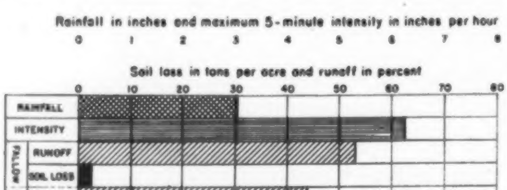


Figure 1.—The effect of plant cover on run-off and soil loss from rain of high intensity, Guthrie, Okla., May 30, 1932. Slope, 7.7 percent.

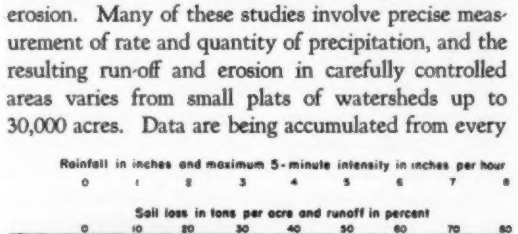


Figure 2.—The effect of plant cover on run-off and soil loss from rain of high intensity, La Crosse, Wis., July 5, 1935. Slope, 16 percent.

rain or snowfall on each of these plats and watersheds. An average of approximately 9,000 measurements all together are being made each year. Figures 1 and 2 present a comparison between vegetative cover and no cover.

Every practice which the Soil Conservation Service is demonstrating so thoroughly in all parts of the country as water-erosion control measures are also flood-control measures. If water is made to creep into instead of to run off the land, the great soil reservoir will have an opportunity to perform its share in the control of floods. This will necessitate the treatment of all land in accordance with its need and adaptability. Cultivation can be carried on where land is not too sloping, but the use of inexpensive practices such as strip cropping, terracing, contour furrowing, etc., will be required.

The recognition by Congress that the Department of Agriculture has a place in flood-control planning and operations is a real step forward which, in years to come, land owners of the Nation should realize to their advantage. At this particular time, the Department is in a better position than ever before to shoulder this great responsibility. The action programs of the Forest Service and the Soil Conservation Service, as well as those of various other departmental agencies, blend together in such a manner as to complement each other, and together they will make an adequate supplement to existing flood-control programs. In the planning phases the Bureau of Agricultural Economics will have a very definite place, and other agencies will likewise make important contributions. The first stage of what appears to be a huge task has been reached, and a small appropriation has been made for planning phases. There will be plenty for everyone to do. Perfect synchronization of all phases of the entire program by Federal and State agencies is absolutely essential. If present plans are carried through this will be assured.

Proper land use is a prerequisite of any adequate flood-control program. Here a West Virginia farmer makes maximum use of vegetation by using timber on his steepest, most erosible areas; grass and hay on intermediate slopes, and a good strip-cropping system on the less vulnerable slopes. Such a plan reduces soil and water losses and makes possible a greater income for the labor expended.

TREES

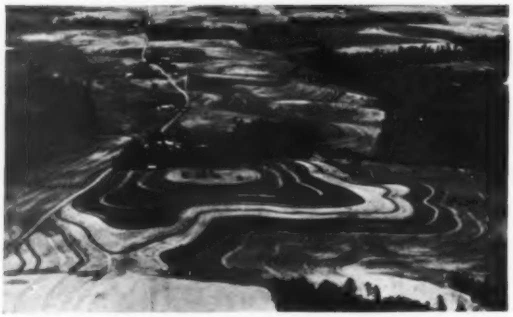
E·V·Jotter[1] describes the place of farm woodlands in the Service program

ONE spring does not make a river and one farm woods has little effect in flood control, but a little patch of woods here, a larger one on another farm, parts of thousands and thousands of agricultural units, make up the striking total of 185,000,000 acres of forest cover. They form more than 17 percent of the total farm area of the United States. They include within their boundaries almost a third of the entire forest area of the Nation. They are located within the more densely populated regions where their effect on the conservation of soil and moisture and the control of floods has immediate as well as far-reaching influence upon the physical, economic, and social structures of our country.

In the New England States the farm woods total almost one-half of the agricultural lands and average 27 acres per farm. The States within the drainage basin of the Ohio, though most highly organized for intensive agricultural crop production, have almost one-sixth of the farm area in woods with from 10 to 15 acres on each farm. Down South, in the States of South Carolina, Georgia, Florida, Alabama, and Mississippi, over two-fifths of the farm land is in woods with an average area per farm of 27 acres.

The methods by which properly managed woods affect run-off are well recognized. The tree canopy and the litter on the forest floor increase the absorption and infiltration of water. Studies made at the time of the Ohio floods showed that in cultivated fields there was much more water at the surface than at a depth of 2 or 3 feet, indicating that the full capacity of water had not been taken up. Nearby forest soils, however, held more water at the same depth than the surface soils of the cultivated fields.

[1] Senior forester, Section of Woodland Management, Soil Conservation Service, Washington, D. C.



Six million farmers own 185,000,000 acres of woods. Good management of these woods is an important part of the flood-control job.

Records taken during a heavy and prolonged rain near Ithaca, N. Y., showed an 88-percent run-off from 14-percent slopes on lands cleared of woods, whereas on adjoining forest and grass areas, with 27-percent slopes, less than one-half of 1 percent was lost through run-off.

Some studies on run-off of flood-producing rain storms of limited duration, made in the Ohio Valley, showed that seven times as much water ran off the cultivated fields as from the forested areas.

These examples of effect on run-off, when multiplied by the vast areas of farmwoods in the eastern United States totalling 147,000,000 acres, or almost a sixth of the total land area, would indicate that they are in the aggregate outstandingly important as a means of flood control through vegetative cover, particularly because they are usually on the steeper parts of the farm.

But what is the condition of the average farmwoods? Grazing stock destroys the vegetation, disturbs the protective forest litter, and impacts the soil. Recurrent fires remove the litter and affect seriously, if they do not finally annihilate, the forest. The present farm woods is a far cry from the "murmuring pines and the hemlocks" of the virgin forest.

In the program of cooperating with farmers in demonstrating how their lands should be operated to conserve soil and moisture, and incidentally to reduce damage by floods, the Soil Conservation Service has a clause in the standard cooperative agreement providing: "The cooperator agrees to protect to the best of his ability from fire all wooded and other areas not used for farm crops." Approximately 4,500,000 acres, or half of the farm land under agreement for erosion control, is now so protected.

The second greatest enemy to the farm woods, and therefore to the influence on moisture conservation, is grazing stock. Farmers, in cooperation with the Service, lead the way in bringing about better wood conditions through the exclusion of stock on approximately 900,000 acres.

More than 200,000 acres on steep slopes, or land otherwise in a condition to add to the flood menace, have been planted with trees on these cooperating farms. Were all similar farm lands treated in like fashion, many more million acres of woods would be added to those already established and now dedicated to woodland growth and use. Desirable, however, as is the conversion of such erodible lands to woodland use, most immediate and far-reaching effects are to be obtained when the farmers put their 185,000,000 acres of woods permanently into the best condition to prevent run-off.

While some farmers recognize their responsibility in using a natural resource in a way to promote lasting human welfare in the United States, most individuals cannot afford to be guided wholly by altruistic motives. There must be economic returns to justify an adequate and permanent land use. Therefore, to show how this may be brought about by proper woods management, there have been established over 8,500 demonstration areas of approximately 5 acres each on the lands of cooperating farmers.

By following the principles demonstrated, the sustained woodland returns made possible will serve to induce the owner to keep such erodible lands in protective woodlands rather than to use them for crops which would not only bring about erosion and undue run-off, but would result in constantly decreasing land returns.

The farm woodlands are generously and widely distributed throughout the country, especially areas in the East. Their distribution and the character of land upon which they are found make them deserving of immediate attention in a flood-control program. At least 15 percent of the land in the eastern United States would be in the best possible shape to prevent floods if the farmers who own the land would rationalize their management of the woods so as to allow Nature to function as it does in the primeval forest or in any decently managed woods. The experience of the Service shows clearly that much more of the farm land should be restored to forest growth, as the logical and best land use, than anyone had previously dared to guess. Proper land use will probably raise the figure of 185,000,000 acres by perhaps as much as 50,000,000 acres. These are indeed important data in any plan of flood control.

VEGETATION CUTS COSTS

By Barrington King [1]

AN INCREASE in the use of vegetative protection for terrace outlet channels in projects and camps in the Southeast, accompanied by a decrease in the cost of this type of protection, sent costs down 57 percent from July to December 1936.

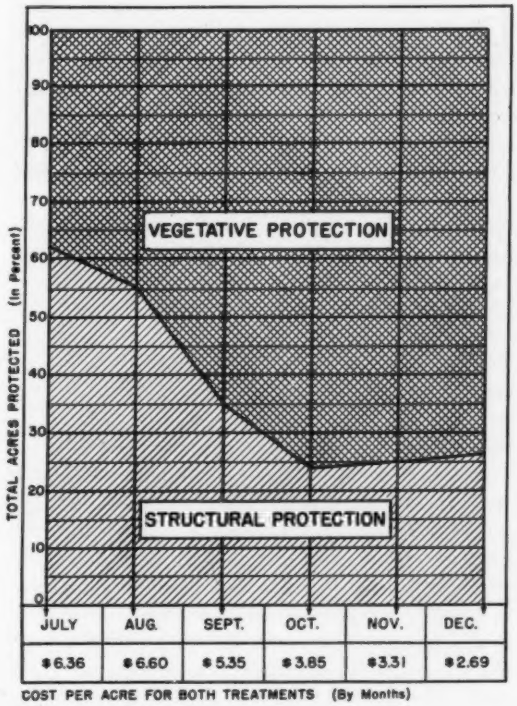
With the exception of a slight rise in the combined costs of vegetative and structural protection during the month of August, the costs were progressively lower each month during the last 6 months of 1936.

At the same time structural protection, which amounted to more than 60 percent of the total in July, dropped to less than 25 percent by November 1 and remained at approximately that proportion of the total throughout the remainder of the calendar year.

The farmer is in better position to contribute toward the cost of vegetation protection than toward the cost of structural protection, although this is not a factor in the reduced costs, since all contributions by the farmer are included in the total cost of treatment.

An indication of better cooperation, however, is seen in the fact that during the past 6 months the percentage contributed by the farmer toward the total cost of material increased from 6.1 to 7 percent, along with the general increase in the use of vegetative protection.

The accompanying graph shows the relative proportion of each type of protection and the cost per acre by months over the 6-months' period.



[1] Associate information specialist, Soil Conservation Service, Spartanburg, S. C.

ECOLOGICAL PRINCIPLES

(Continued from p. 54)

upon makeshift actions and temporary expedients. These broke down because the plants used were lacking in economic qualities, or the integrations and plans did not conform to normal plant successions.

There is definite need, as an aid to soil conservation, to develop crop and erosion-control plants of superior economic quality and to devise integration and vegetative cover management which will follow such patterns of plant succession as will give sustained yields at all times.

Such adjuncts as debris basins and check dams must play an important, but temporary, part in the erosion-control program. The heavy toll taken by erosion on lands under tilled crops must be overcome by farming systems that are in harmony with the normal climatic and vegetational processes. An approach to this is now being made in the form of strip cropping, but it is possible to go far beyond this in the direction of soil-building vegetational systems. An understanding of Nature's principles and methods has already been attained in fair measure with respect to climax vegetation, the processes of plant succession, and the use of plant indicators in determining what has happened and what can be made to happen.

ANNOUNCING FOR OCTOBER

Next month's leading feature will be an article by Dr. C. W. Thornthwaite, "The Hydrologic Cycle Reexamined."

ENGINEERING PHASE

T·B·Chambers[1]
on

The use of vegetation in mechanical erosion-control structures

EROSION control must follow nature's precepts. A protective covering of vegetation is the most effective measure against the impact of falling raindrops and the scouring action of running water, and, in addition, it assures the infiltration needed to reduce run-off. On cultivated slopes it is, however, impossible to reproduce a native cover, and the erosion specialist must resort to management of the cultivated cover to simulate, as nearly as possible, natural conditions. Even then, it often becomes necessary to employ supplementary or complementary mechanical measures.

The erosion control engineer is faced by many problems. In the forefront is the fact that adequate construction must be had within the limits allowed by land values and land-use adaptability. Conventional materials, such as concrete or masonry, are usually too expensive to be used for lining channels, paving spillways, or for many other purposes where their use would ordinarily be indicated in another type of program. While such materials can be economically used in a few places where special crops of high value are grown, or where run-off from large drainage areas is concentrated, their costs are often prohibitive on the vast areas devoted to conventional crops. For a cheap, effective construction material the engineer must turn to vegetation. But in using vegetation the problem of design becomes complicated because there is no background of experience to indicate values of strength or resistance to wear that such materials will afford when subjected to the forces of running water. Cut-and-try methods have been necessary in all cases where vegetation and other nonconventional materials of construction were used, which necessarily retarded the progress of the work. Field experiments are now being conducted which have partially developed safe values for design purposes. Where actual values are not known the only recourse is to play safe by using values somewhat below the indicated maximum, which results in more expensive structures. Future research and a critical analysis of field practices should develop factual data that will enable engineers to use definite values for different types of vegetation when used under varying conditions of soils, slopes, and climates.

In serving as a channel lining, vegetation is subjected to much greater destructive force than would be true on undisturbed slopes where normally run-off would flow in thin sheets at low velocities. Special care must be used in preparation of the seedbed. The soil should be well fertilized and it is usually necessary to provide a temporary protection until a dense sod is formed. The use of what might be called "heavy duty" vegetation in such treatment requires relatively high installation costs and careful maintenance throughout the life of the structure.

Protection of Channels

Under favorable conditions the use of vegetation as a lining material for terrace outlet channels is highly desirable. It will ordinarily be subjected to only short periods of flow occurring at infrequent and irregular intervals. These will usually promote rather than retard growth. Where slight damage occurs from an exceptionally high flow, there is generally ample time for healing by new growth before the next flow period.

Vegetated outlets are used for low-velocity channels in the eastern half of the United States from Florida to Wisconsin. Bermuda grass is the most effective in the South, while farther North ryegrass and the pasture mixtures are used. In locations where adaptable, Kentucky bluegrass has proved highly successful.

An example of the use of vegetation in channel lining is cited from the experience of field engineers in Texas. When the new demonstration projects were established there in 1935, vegetated outlet channels were designed for a velocity of 5½ feet per second. The prevailing topographic and slope conditions limited the drainage area to 30 to 50 acres. On larger watersheds, where the velocity when concentrated in one channel would exceed 5½ feet, it was planned to use concrete or masonry overfall dams to protect the channels. Subsequent field tests proved that channels lined with Bermuda grass were capable of sustaining a velocity of at least 8 feet per second for period up to 30 or 40 minutes. This permitted drainage of over 100 acres into a vegetated channel and permitted a reduction of 95 percent in the contemplated masonry structures. Much lower costs were entailed and, at the same time, better farming practices were maintained by utilizing the channel area for grazing and forage production.

(*Continued on p. 62*)

[1] Head, Engineering Section, Soil Conservation Service, Washington, D. C.

1. *Kudzu protecting a steep bank.*
2. *Vegetated meadow strip serving as outlet for terrace discharge.*
3. *Terrace outlet channel protected with vegetation. Mulch has been used on the bank slopes in connection with seeding.*
4. *Small wire dam protecting gully head while grass is being established.*
5. *Close growing filter strip of vegetation above diversion channel.*
6. *Oat strips over level terrace serve as filter for terrace channel and protect ridge against damage from overtopping.*
7. *Highway ditch and back slope protected by Bermuda grass.*

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Vegetation for Soil Conservation

(*Continued from p. 60*)

Outlets may consist of well-vegetated meadow strips prepared by seeding or sodding a natural drainage way. When feasible, this use is to be preferred to constructed channels, because the preparation of the natural drainage way is less expensive and it affords more income from the production of hay or pasturage.

A farmer in North Carolina objected to establishment of a lespedeza and grass meadow strip across one of his largest and best fields. His opinion was that too much land would be retired from cultivation. The next season he cut 7½ tons of hay from the strip and received a higher income per acre from it than from any other part of the farm. At the same time the strip afforded perfect protection as an outlet for the terrace system.

The flow line of gullies and natural channels may be successfully protected by dense, close-growing types of vegetation when the soil and slope are favorable and the velocities are not too great. This method is used most often where it is impractical to divert water away from the gully. Sometimes it is necessary to use low, temporary dams for immediate protection while vegetation is being established. By the time the dams are no longer effective the vegetation may ordinarily be relied upon for permanent protection. Under more favorable conditions native vegetation will often afford ample protection if the gullied area is protected from grazing and fire while a cover is being established.

Water should not be concentrated any more than necessary. Locations will often be found where individual terraces or other water-carrying structures can be emptied on to pasture or woods, obviating the necessity of a prepared channel. Here vegetation is not used as a material of construction, although it does serve in conducting concentrated water to a lower elevation.

Spillways

Dams for soil- and moisture-conservation purposes are often located on small watersheds, or in other places where flow is infrequent, and masonry spillways cannot be afforded. The erosion engineer meets this situation by placing dams in locations where a wide natural surface can be used for discharging the overflow at low velocities. Low velocity and infrequent flooding permit native vegetation to withstand successfully the cutting force of the water, even in the more arid sections of the country where a sparse growth is common. By flooding wide areas, more vegetation and a healthier growth are produced from the increased moisture, affording better range or pasture and additional protection to the dam. In such situations the judgment of technicians must be relied upon for safe design, since no definite values can be assigned to vegetation under the wide variety of conditions encountered.

Terraces

Vegetation is sometimes used in connection with terraces to protect the ridge against scouring and cutting because of overtopping. Drainage-type terraces are designed with a grade that will not produce erosive velocities and consequently protection is not needed in the channel although it is desirable immediately above. Many farmers and technicians object to the use of close-growing vegetation on newly constructed terrace ridges since it prohibits the proper seasonal maintenance of the terrace, and its protective value is doubtful on graded terraces.

On the level, absorptive-type terrace close-growing vegetation offers very definite protection from blowing and from water damage when overtopped and should be maintained continually on the ridge. The level terrace is designed to impound all run-off from normal rains, but the ends are left partly open as a safeguard to discharge run-off from exceptionally high rainfall. Even with this protection, overtopping occurs occasionally and, unless protected with a dense vegetation, the ridge may be severely cut and the slopes eroded. Vegetation should also be used at the terrace ends where flow may reach erosive velocities.

Protecting Banks

Almost any bare, unprotected bank may be stabilized with vegetation if the concentration of water flowing over it is not too great. Gully banks, stream banks, and the slopes of highway cuts and fills may be amply protected under most conditions. Shrubs, vines, or trees may be used in addition to the heavy, tufted grasses, depending on the nature of the job to be done and the time limits. On places where heavy concentrations occur, it may be necessary to aid growth by fertilizing, soil conditioning, or structural protection, to establish a "heavy duty" vegetal cover. Individual terrace outlets over banks of 45° slopes have been successfully protected with Bermuda grass established on a well-fertilized layer of topsoil.

Vines having the power to take root from stolons are particularly valuable for protecting steep banks.

Vegetation for Soil Conservation

It is not necessary to attempt planting on the steep surfaces, inasmuch as the vines can be planted above or below and will spread from there. Vertical gully banks 30 feet high have been successfully stabilized with kudzu vines. Dense-rooted shrubs are valuable, as well as trees, and are used where they do not interfere with other uses of the area.

Protection of Diversion Channels

While vegetation is seldom used on diversion channels it is best to have the protection of close-growing vegetation immediately above it if the effectiveness of the channel is not to be impaired by excessive silting. Soil material moved by erosion on cultivated or unprotected areas above a drainage channel will be deposited on entering the channel. A close-growing, permanent strip of vegetation 2 or 3 rods in width immediately above the channel is usually sufficient. When located immediately below a pasture or wooded area additional protective strips are seldom necessary.

Strip Cropping

The action of strips of vegetation in removing soil material from running water is entirely mechanical. Strips of relatively narrow width, if the vegetation is of sufficient density to spread the water and check its velocity, have proved highly effective as desilters, and are valuable in holding eroded soil material on the slope. When used in connection with diversion channels or terraces the erosion hazard is further reduced. When strips are used independent of mechanical measures the water—except for the relatively small amount retained by increased absorption within the stripped area—will continue down the slope in increasing amounts to erode unprotected areas. As in the use of vegetation in structures, additional experimental data is needed before the soil conservationist can attribute definite values to strip cropping as an erosion-preventive measure.

Methods of Establishing Vegetation

In using vegetation as a structural material where a definite value must be placed on its ability to withstand external forces, it is necessary that its density, vigor, and root growth conform to a standard. Haphazard methods of seeding, sodding, or planting are not usually satisfactory and improved methods have been developed by engineers working in cooperation with other specialists. When solid sodding is used the strips must be cut to uniform thickness and width so that when placed in the new location the pieces will fit closely and accurately, and form a smooth, uniform surface. To insure immediate and vigorous growth a bed of topsoil and fertilizer is generally necessary. Methods of strip sodding have been greatly improved by field engineers in the last few years. The strips are countersunk in close-fitting trenches placed at right angles to the direction of flow and are tamped in place. The strip, while serving as a base from which a grass may spread over the entire area, also acts as a barrier to scouring and channeling. Fertilization is very necessary with strip sodding in order that the intervening areas may be covered as quickly as possible.

A mechanical method of sprig sodding has been developed by engineers for use in sodding pastures or banks with Bermuda. Pulverized turf is scattered with a manure spreader and then disked. The method has proved adaptable where considerable time is allowable and has reduced the cost of sodding highway banks from 8 cents to 2 cents per square yard.

In establishing a channel lining by seeding, it has been found necessary in most cases to use one to two inches of mulch, securely held in place, to prevent seed being washed away, and to give increased moisture and protection to the young plants. Mulching is also used when seeding on banks and severely eroded areas of steep slopes. Straw or other vegetal litter and brush have been successfully used as a mulch.

Machines to facilitate handling of vegetal materials have been developed, including numerous types of sod-cutters and loaders, contour furrowing machines, and seed harvesters for gathering seeds of wind grasses and other unusual plants that offer promise as soil binders.

In using vegetation the engineer must be sure that protection will be afforded when needed. Seasonal and climatic conditions present many hazards. Frequently overgrazing, burning, or disease so damage vegetation as to make it useless for erosion-control purposes. It is important that the plants used are adaptable to the location, that the soil has ability to produce, and that the growth characteristics of the plant are fully known. In some areas the highest rate of run-off occurs immediately after the snow melts and before any growth begins. Under these conditions a type of vegetation such as perennial grasses that form a heavy protecting turf would be necessary. In

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SLOPE USAGE

S·B·Detwiler[1] reviews some of the opportunities for improved hillculture farming

SAFE and profitable use of sloping agricultural lands constitutes an important soil-conservation problem. Cultivation of slopes is responsible for severe losses of soil and water; yet the financial needs of the farmer are often such that he cannot afford to retire these lands from tillage and devote them to less remunerative forest or grass crops. Hill-culture research aims to find sound erosion-control practices that will provide the farm owner with the requisite supplemental income from safe use of steep, erodible lands.

Hill culture is founded to a considerable extent upon the principles evolved in Bergcultuur in the Dutch East Indies, and on the plan for "mountain agriculture" long advocated by Dr. J. Russell Smith of Columbia University. As applied to the United States, hill-culture research aims to perfect an ecologically correct and economically practicable system of managing erosion-resisting vegetation consisting of superior selections of trees, shrubs, and perennial herbaceous plants. In addition to fully conserving the soil and water on sloping farm lands, the purpose is to produce early economic returns from plant products having high potential commercial values such as tannins, oils, waxes, plastics, food, forage, and specialty products which will not compete injuriously with established domestic crop production and marketing.

Agriculture and horticulture apply scientific principles of economic plant improvement but have limited regard for ecological principles in managing vegetative cover. Silviculture is founded on sound ecological management but is limited in the application of plant improvement principles, since forest crops are not primarily adapted to production of fruits, foods, and forage products which thus far have been the main consideration in plant improvement research. Hence, hill-culture research occupies a distinct field of its own, and offers opportunity for real service in the advancement of erosion-control practices founded upon scientific management and use of superior perennial vegetation yielding early and valuable crops on sloping farm lands.

Ecological methods of managing agricultural crops have made the greatest advance in the Dutch East Indies and Malay States under the incentive of specialty crops from trees and shrubs such as coffee, tea, spices, cacao, cinchona, and rubber for export trade. There, clean culture under high rainfall conditions rapidly depleted soil fertility, and scientific erosion-control farming was evolved through necessity. The original meaning of Bergcultuur was the cultivation of mountain and hill lands, as opposed to farming on level lands. About 40 years ago some of the large plantation estates began work to improve quality and quantity of yield through plant selection and breeding, and to experiment with methods of maintaining soil stability and fertility through management of perennial ground covers.

During the past 25 years, rapid progress has been made due to the establishment of hill-culture experiment stations and publication of "De Bergcultures", a weekly journal sponsored by the General Agricultural Syndicate and the experiment stations of Netherlands–India. The chief methods employed are maintenance of shrubby ground covers, especially leguminous shrubs; protective "shade" trees of leguminous

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THE PICTURES

(Courtesy Bureau of Plant Industry)

1. *Fruiting branch of pawpaw.*
2. *Pawpaw tree of unusual size.*
3. *Japanese quince (left) and pawpaw (right).*
4. *A million Japanese persimmon fruits on storage grounds, Fo Tzu Chuang, Japan.*
5. *Shipmast locust posts (left), good as new after 60 years' service. Those on right still useful after 110 years in ground.*
6. *Wild hazelnuts (left) and an improved strain (right).*
7. *Ginkgo trees on the Mall in Washington, D. C.*
8. *Fruiting branch of the Ginkgo. A native of China, widely planted here for ornament. The nut has a sweet, edible kernel.*
9. *Branch of Russian olive laden with fruit useful for jelly and bird food.*

10 and 11. *A new hybrid of the Chinese hairy chestnut and the Chinquapin; blight resistant, prolific and hardy from Maryland south.*

12. *A superior Japanese persimmon.*
13. *Chinese holly. Crimson berries and glossy leaves, superior for Christmas greens. Thrives in hot, dry climates.*
14. *Native sumac. A valuable erosion-control plant yielding a high grade of commercial tannin.*
15. *Luscious fruits of jujube.*
16. *Ordinary, crooked black locust (left) and the superior shipmast locust (right).*

[1] Head, Section of Hill Culture Research, Division of Research, Soil Conservation Service, Washington, D. C.

(*Continued from p. 64*)

species; intensive selection, breeding, and testing of crop trees and shrubs; economical methods of vegetatively propagating the selected strains of crop plants; green manure pits, silt pits, simple terraces, and other erosion structures if required; and effective organization, upkeep, and protection of the plantations. The system is especially dependent upon managed shade and ground cover vegetation and improvement of crop plants through systematic and intensive selection.

Many excellent perennial plants are now grown as farm crops, but as yet no one has attempted to develop for the United States a complete and scientific soil-saving farming system based on effective integration of such plants. Our factory-like methods of farming are destroying our source of life—the soil itself. Chemistry can aid in making hill culture profitable through devising ways to use our uncultivated plants, species of the fields, woods and thickets. Plant breeding can do even more than chemistry, because so few of our native plants have been worked with seriously for improvement of their fruit, yield and erosion-control qualities.

Superior varieties of nuts are so well recognized as a crop for erosible lands that the Tennessee Valley Authority has employed a nut-culture specialist. There are a dozen or more recognized varieties of black walnut yielding nuts of high cracking quality, and several good butternut varieties. The Japanese heart-nut is considered by many to be the best of all nuts. Hardy varieties of English walnut grow as far north as Ontario, as do also hard-shell almonds. There are many superior varieties of shagbark hickory, and also a cross between this species and the bitternut which has the rapid growth so often found in hybrids, bears early and yields well of fine-flavored, thin-shelled nuts. Many superior forms of pecan selections have hill-culture value and several pecan-bitternut hybrids appear promising.

Dr. Kent Beattie, of the Bureau of Plant Industry spent 3 years in the Orient making intensive selection of the best forms of Chinese and Japanese chestnuts and his work will be of especial importance in hill-culture development. A hybrid chinquapin is available, as are also selections of the American hazelnut. Nut culturists predict that continued selection of the American hazel will develop nuts superior to the European filbert, without the damage from blight which often makes filberts hard to grow here. The Chinese tree-hazel and large-fruited forms of beech offer additional opportunities. In warmer regions, pistachio nuts, selected strains of California hybrid walnut, soft-shelled almond, and Jojoba nut have possibilities. The latter grows wild in arid sections and the nut meat contains 50 percent oil similar to sperm oil.

Various pine nuts can be developed for greater commercial use through selection methods. Large quantities of unselected pinon nuts are marketed each year, beside furnishing an important part of the diet of many Indians.

The wild apricot of Turkestan grows in a cold, arid region and yields fruit of surpassing flavor. The pits as well as the flesh are a staple food of the natives, having a well-flavored and nourishing meat. Selections have been made by the Bureau of Plant Industry for fruit having quality, size, and richness of flavor.

Other edible fruits for hill-culture development are numerous. Here special opportunity exists for choosing hardy native trees and shrubs of high erosion-control value and possessing superior fruit for use in jellies, fruit juices, dried fruits and preserves as well as for forage, waxes, oils, and other commercial products. The Hansen bush-cherry has been developed through selections covering 40 generations and has hillculture value, as do also the selected strains of the very hardy Chinese bush-cherry. The native blueberries, high-bush cranberry, and other viburnums, service berry, various wild plums and wild grapes, and papaw, have been selected for superior fruiting qualities. Selections are available of native persimmon for seedless fruit, large fruit, early and late ripening, and high yield; and hardy varieties of Japanese persimmon grow as far north as Tennessee.

The jujube in the Southwest offers possibilities for development without cultivation. Next to dates, the native persimmon and the jujube have the highest food value of any of our fruits because of their exceptionally high sugar content. Japanese quince grows well without cultivation, is free from the most serious troubles of the European quince, and furnishes industrial products. A native elderberry has been developed that produces heavily. Many superior heavy-bearing mulberries are available, and, like the persimmon, the luscious fruit has possibilities as feed for domestic animals.

All of the Elaeagnus species are good erosion-control plants and several of these bear large, well-flavored fruits, fine for jelly. European dogwood produces fruits as large as pie cherries which are so relished by children and birds that it is difficult to collect seed. Himalayan blackberry and the Oriental trailing raspberry are now in use for erosion-control planting; both

are resistant to the troubles of cultivated Rubus and yield marketable fruit in abundance.

The commercial fruits adapted to hill-culture production are barely touched upon in the preceding list. Legumes for forage, waxes, insecticides, resins, oils, and tannins are equally extensive. Several of the new shrubby lespedezas have done well in erosion-control plantings, and offer possibilities as ground-cover plants, as does crown vetch. With valuable new plants of this sort, there are also opportunities to produce seed commercially. The American Genetics Association held a contest several years ago to locate honey locust trees producing thick, sweet pods suitable for a rich food for cattle as well as offering commercial possibilities for resins, wax, and sugar or syrup. Mesquite and carob produce heavy crops of beans in the Southwest that are highly valuable for forage and industrial uses, and can be improved by selection.

Shipmast locust is a variety of black locust which has a tall, clean, very straight trunk suitable for piling, posts, sills, ties, etc. Its ordinary life as a fence post is from 50 to 125 years. It is equal in growth rate to common locust and not subject to as serious borer damage as is the latter. Work done in the Bureau of Entomology and elsewhere indicates possibilities for developing a black locust even superior, for erosion-control purposes, to the Shipmast variety. It is possible to develop a thornless black locust through selection. Special values of locust and other leguminous trees are their protective and fertilizing properties when properly integrated with other trees and shrubs grown for their commercial products.

Tannin-producing crops offer favorable opportunity for the new type of farming. Sicilian sumac is imported by the tanners in considerable quantities and our native sumacs are also used. R. W. Frey, of the Bureau of Chemistry and Soils, believes selections of native sumac can be made to equal the selected Sicilian forms for superior tannin. The Sicilian sumac industry is highly developed and exportation of plants or seed is prohibited.

The entire world uses about 940,000 tons of 25-percent tannin extract annually, of which about one-half is used in the United States. Chemical substitutes for tannin were developed about 1880 and have been in commercial use for the past 35 years; synthetic tannins are used to improve color and accelerate tanning. Mr. Frey does not expect chemicals to supplant the vegetable tannins for heavy leather of which it is estimated that some 350,000,000 pounds per year are made in this country.

At present the United States imports about 50 percent of the tannin materials it uses, and over 60 percent of the domestic material is derived from chestnut wood. Chestnut is now being steadily destroyed by chestnut blight, and in a relatively few years compared with the time required for trees to grow the tannic acid extract business based on native chestnut wood must cease for lack of wood. The United States appears to be increasingly dependent in the future on imported vegetable tannin materials; hence this country might find itself in difficult circumstances in case of war.

The development of a new domestic tannin crop is of great interest to the erosion-control program, since it offers a chance to utilize large areas of erosive soils in growing perennial plants high in tannin value. Mr. Frey and other tannin experts consider canaigre, a sour-dock plant native to the Southwest, a worthy possibility. Mexicans and Indians have long used the heavy root of this plant for tannin purposes. The supply of native plants was nearly exhausted by collection and shipment to England and Germany about 50 years ago. Canaigre is recognized abroad as furnishing a first-class tannin. The plant can be grown with or without cultivation over one-fourth to one-third the area of the United States. A program of research on the possibilities of canaigre is now under way in the Department.

The production of holly and other similar plants for Christmas greens is another potential industry for hill culture. Many farmers now secure income from holly greens—estimated at $150,000 per year in southern Maryland. For Christmas holly, the Chinese holly, *Ilex cornuta*, is especially desirable because of its relatively fast growth and handsome berry production, but this species seems best adapted to the drier and warmer regions. Carefully selected native holly trees need to be worked with in the East.

Maple sugar orchards furnish a common example of applied hill culture; maple sirup and sugar now provide regular and important cash returns to many farmers. Underplanting maple orchards with economic shrubs, such as the improved hazel nut, high-bush cranberry, and blueberry, would tend to improve conditions for growth and yield of the maple trees and furnish an additional source of income. A recent study has shown that maple orchards having a shrubby ground cover have better conditions for their growth.

Hill-culture plantings, after the annual crop values of the plants are no longer profitable, may furnish a final

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PROPAGATION

An article by F·J·Crider[1]

Little known plants find their place in the sun

TO CARRY forward effectively the vegetative soil-and moisture-conservation program of the Soil Conservation Service, plants are needed—an inconceivable number of plants—for gully slope stabilization, to prevent sand blowing and to reclaim bared lands, to control the insidious land destruction caused by sheet erosion, for protection of terrace outlets and for many other purposes connected with the conservation of soil and water. The nurseries of the Service serve as the ready source of supply through which all propagation materials used in erosion control are made available to the using agents—agronomists, foresters, and biologists. Virtually every member of the field force—be he botanist or waterboy—is a plant hunter. The possibility of discovering a hitherto unused species or variation possessing valuable characteristics useful in erosion control colors the daily routine of the worker. The quest for plants with existent, outstanding erosion-resistant qualities goes on continuously. Thus, by adding to those already recognized as useful, the nurseries bring together large collect ons of both native and introduced plants for observation and eventual quantity production and utilization.

During the nursery observational period all possible data are obtained having to do with the characteristics and methods of handling the plant and its adaptability to particular environments and uses, looking toward its ultimate establishment in the field or under natural range or forest conditions, as the case may be. This serves not only as a further indication of its practical values but provides essential information for subsequent use by both the nurserymen and those more directly responsible for planting out the material on demonstration project and C. C. C. camp areas.

For those plants agreed upon as possessing the desired characteristics for general field utilization, effort must be made to determine successful methods of propagation, the practices finally adopted to be simple, easily applied, and adaptable to quantity multiplication. Also, there must be found out, particularly in the case of plants such as grasses and legumes, all the facts possible regarding the common though highly important farm practices, such as proper rate and depth of seeding and time and method of planting, as well as any other information essential to successful establishment under conditions where the plants can be most effectively used in the soil- and moisture-conservation program.

As to what constitutes erosion-resisting characteristics in a plant, this depends in large measure upon how the plant is to be used and the location to which it is to be adapted in the revegetation program. This can perhaps best be illustrated by typical examples. It being known that a rapid growing, stoloniferous grass was badly needed for quick cover on the heavy soils throughout the Central and Northern Great Plains, attention was directed to western wheatgrass, *Agropyron smithii*. Adapted to such soils and having excellent soil-binding properties, some of the better types or variations were sought out and assembled in the nurseries for observation and quantity increase. At the same time, large quantities of seed were harvested from native meadows. The fact that this grass produces excellent yields of seed which is easily harvested and that the establishment of young seedlings is fairly simple, adds to its value in general erosion-control operations. Favorable reports resulting from its rather wide use in reseeding and soil-protection operations in certain sections seem to justify the intensive observational studies in the nurseries.

Buffalo grass, *Buchloe dactyloides*, is another example of a stoloniferous plant which, by reason of the assemblage of desirable variations in the nurseries and the development of special methods of harvesting the seed under natural conditions, fits ideally into the observational phase of the nursery program. This native species is dominant in the short-grass areas of the Great Plains, forming a dense sod where protected from over-grazing. The species is dioecious, the male and female plants usually being found in colonies, but more or less intermingled. The seed is produced in a short-stalked bur that makes harvesting by mechanical means extremely difficult. The seed is also subject to a fungus disease which materially lowers its viability during certain years. The grass can be satisfactorily propagated, however, by means of vegetative cuttings, and extensive use of this method is now being made in the sodding of terrace outlet ditches and gully structures. Buffalo grass is very nutritious and is utilized widely as a forage plant throughout the range of its adaptation.

Always on the lookout for erosion-resisting plants adapted to a wide range of soil and climatic conditions,

[1] Head, Section of Conservation Nurseries, Soil Conservation Service, Washington, D. C.

field workers early recognized that Canada wild rye, *Elymus canadensis*, possessed these general characteristics, and this grass is now being propagated for seed increase in the nurseries of the Northwest, with special selections under observation for specific uses on demonstration projects. It forms an abundance of vegetative growth and is easily established from seed. The species is not very palatable, a quality which of itself may be considered an asset where there is a tendency toward too heavy grazing. Many of the more palatable native grasses have practically disappeared from our ranges due to overgrazing. Given a chance under proper climatic conditions, Canada wild rye should aid materially in the reclamation of soils that have been overcultivated and overgrazed.

It is considered particularly fortunate when a plant shows throughout the observational period several distinct characteristics required for the erosion-control program. Such a plant is sheepbush, *Pentzia incana*,[2] the shrubby perennial from South Africa. The program requires plants resistant to drought, with procumbent growth habit for prevention of sand blowing as well as sheet erosion. Sheepbush, which becomes dormant during the dry season and is immediately rejuvenated with the first rains, is extremely drought-resistant and is a distinctly layering shrub. In times of severe drought when other vegetation fails this plant can be depended upon for forage for sheep. In addition it has the distinct advantage of reseeding under natural range conditions. Originally it was thought that this shrub was adaptable only to the extreme Southwest, but recently it was found to withstand a temperature of 17° (Fahrenheit) below zero, thus making it of value for wide adaptation in regions throughout much of the country where prolonged droughts occur and where wind erosion is severe.

Being constantly on the alert for plants possessing high erosion-resisting values combined with high soil-building properties, the nurseries in the Southeast are just now starting to increase in quantity a bushy variation of lespedeza which gives unusual promise for these particular purposes. Both the agronomists and the wildlife people are interested in this legume as it is known that the plant can be used successfully in the Southeast for strip cropping and that its seed is relished by birds. The quantity production of this highly desirable accession will go forward during the next year at the Clanton, Ala., nursery where land has recently been purchased for a large combination observational and quantity production nursery unit.

[2] This foreign species was described in vol. 2, no. 7, Soil Conservation: Observational Plantings in the Nurseries.

Blue bunch wheatgrass
(Agropyron spicatum)

Western wheatgrass
(Agropyron smithii)

Beardless wild rye
(Elymus triticoides)

Mountain bromegrass
(Bromus marginatus)

In the Northeast, centered at the observational nursery near Ithaca, N. Y., notable results are being obtained in the assembly of species and strains of grasses and legumes possessing both soil-building and soil-binding characteristics. Wild white clover, an introduced species from England, is worthy of special note. This plant is compatible with grasses and other clovers, and like other legumes enriches the soil with an accumulation of nitrogen and organic matter. Pasture-type timothy and orchard grass as well as improved strains of rye grass are now being grown here prior to their production in quantity for use on demonstration projects.

It is a significant fact that these and many others of the selections showing most promise for use in the erosion-control program of the Northeast represent the product of European plant breeding stations. This greatly simplifies the work of our Service which now merely consists of the assembling, observational testing, and increase of strains that were developed previously through years of painstaking research.

Plants which maintain hardiness under the most arid of conditions are necessary in order to lick the severe erosion problems of the Southwest. Two grasses showing great promise in this section are the lovegrasses, *Eragrostis curvula*, and *E. lehmanniana*, which came to us from South Africa. In the nurseries of the Southwest they have passed the initial testing stage and, showing pronounced erosion-resistant characteristics, are being increased in quantity for the first time for practical utilization. They produce an abundance of vegetative growth and heavy crops of seed, with the further desirable quality of propagating both by seed and vegetatively. Although appearing not to be winter hardy in the north, preliminary trials indicate they may have a place in the agriculture of our more northern regions as annuals due to their ease of seeding and rapidity of establishment.

Although slower in immediate results than the grasses and other forage crops, observational plantings of the tree and shrub types include species which have already shown sufficient evidence of superior merit to warrant their quantity increase. Into this category come the Ozark white cedar, *Juniperus ashei*,[3] and the Japanese trailing raspberry, *Rubus parvifolius*, both of which possess the characteristic of being highly resistant to plant diseases, as well as supplying abundant food for birds. The raspberry, in particular, on account of its rapid growth and stoloniferous, mat-forming habit, has high soil-binding, erosion-resistant properties. This lucky find was brought into the United States by the famous plant explorer, P. H. Dorsett, of the Division of Plant Exploration and Introduction, Bureau of Plant Industry, in 1929. Since that time the plant has been under investigation by Dr. G. M. Darrow of this Bureau, from whom propagation stock was obtained for distribution and trial in our observational nurseries.

Heavy litter-producing capacity, ability to withstand competition with less valuable plants, tolerance of unfavorable soils, desirable fruiting habits—all these and many other qualities are sought in order that trees and shrubs for windbreaks, woodlots, buffer strips, game food and cover, and general soil stabilization may contribute in fullest measure, along with grasses and other forage crops, toward rounding out the vegetative soil- and moisture-conservation program of the Service.

[3] Described in this issue, by Charles F. Swingle: A Promising New Cedar for Erosion Control.

ENGINEERING PHASE

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warmer climates a stoloniferous grass, overseeded with rye or other winter grasses when the occasion demanded, would offer complete protection to channels the year round.

The soil-erosion engineer has made marked progress in the development and use of vegetation in conjunction with mechanical erosion-control measures. Very little was known prior to 1933 about the possibilities of these measures. The erosion engineer desires to continue their improvement, together with a more complete usage of vegetation as a construction material. The development and enlargement of his activities in this direction will depend upon obtaining facts on which he can rely. He hesitates to stake his professional reputation on the use of materials about which he knows next to nothing, and which are susceptible to so many hazards. It has been said by a man high in the engineering profession: "A true engineer is as much born as a poet or any other artist, but he is cradled on palpable material and nursed on facts, not metaphysical ideas."

SUBSCRIPTIONS ACCEPTED

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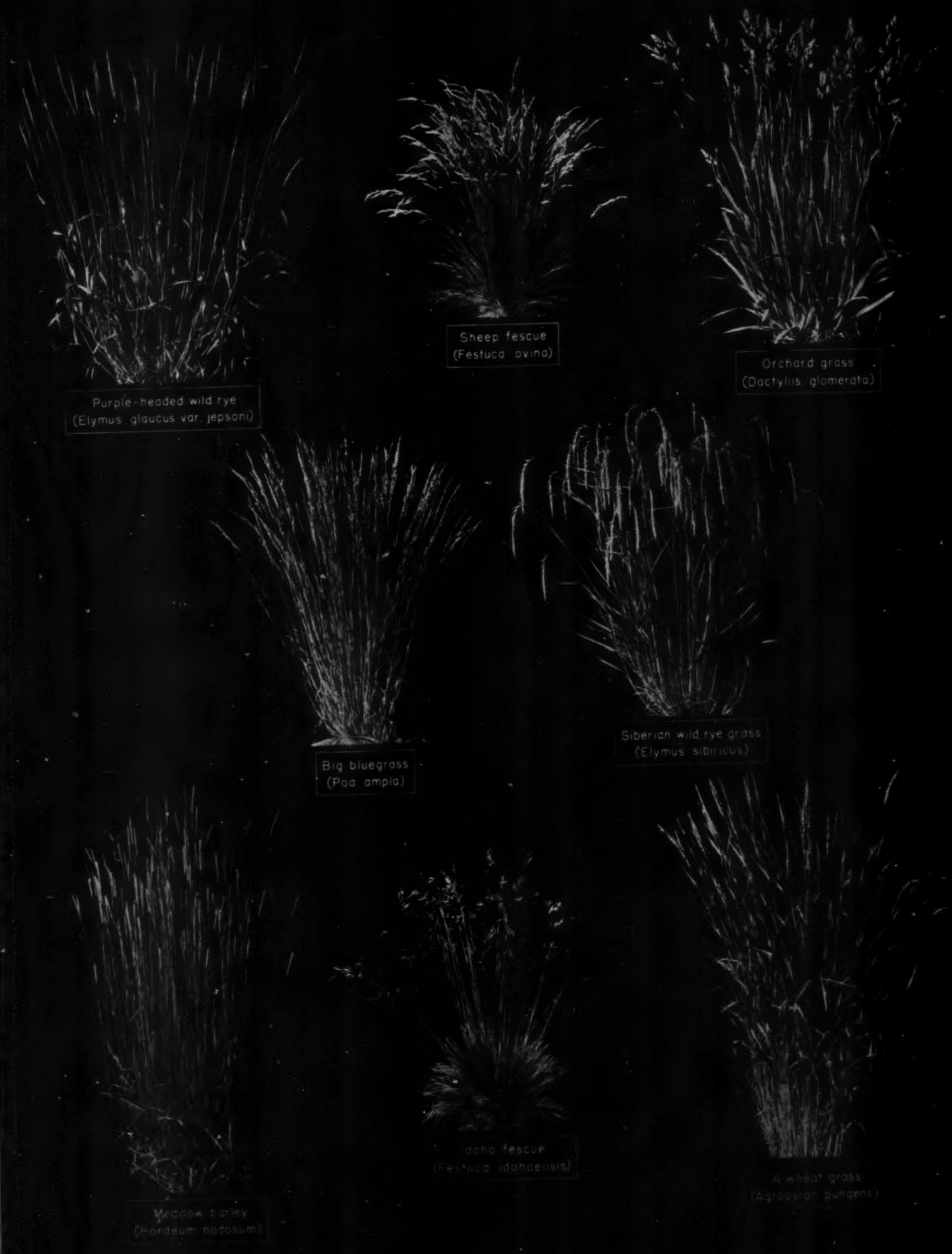
OCTOBER FEATURE

"The Bermuda Grass King" is the title of an article by Angus McDonald, which will appear next month.



Purple-headed wild rye
(Elymus glaucus var. jepsoni)
Sheep fescue
(Festuca ovina)
Orchard grass
(Dactylis glomerata)
Big bluegrass
(Poa ampla)
Siberian wild rye grass
(Elymus sibiricus)
Meadow barley
(Hordeum nodosum)
Idaho fescue
(Festuca idahoensis)
A wheat grass
(Agropyron pungens)

GRASS SEED

Quantity production in nurseries is explained *by* M·M·Hoover[1]

Power seed stripper developed by Tucson nursery. Collecting blue grama seed.

THE production of grass and other forage crop seed in quantity by the Section of Conservation Nurseries follows as a normal sequence in the development of the plant observational program of the Service.

When a particular accession, whether native or exotic, has successfully passed the initial observational tests and demonstrated its value in soil and moisture conservation, it is then ready to be grown in plats of sufficient size to produce seed in quantity for use on demonstration project areas. The observational tests supply fundamental information regarding the soil and climatic range of a given accession as well as growth characteristics and cultural practices necessary for successful establishment; but the production of seed in quantity is a specialized nursery activity contributing to the quantity utilization of the plant in various erosion-control practices.

The production of grass seed in quantity involves a change in cultural practices from those found most feasible on the nursery proper for handling the various accessions during the period of their initial observation. Although the primary purpose of the increase plantings is the production of seed in quantity, nevertheless the ease of propagation by practical methods and equipment in common use by farmers and seed growers are very important factors in determining the general usefulness of any of the new accessions in the vegetative program of the Service.

Methods of planting, harvesting, and threshing the various grasses have been developed at nursery centers where facilities were available for conducting this work. Equipment in general use has been adequate for most cultural operations; however, many of the new and better grasses require special adjustments to facilitate their most satisfactory handling—as regards both planting and harvesting operations. It is the general practice to employ, as nearly as possible, the same planting, cultivation, harvesting, and threshing methods used for increase seedings by private seed growers operating in the community.

Particular attention and care are given to such matters as rate, method, and date of seeding, as well as to all subsequent cultural practices, in order that this information may be made available to the private seed grower if and when the demand for seed of a given accession seems to warrant such general production.

Although most of the accessions now being increased in the nurseries have been the result of satisfactory performance in preliminary observational plantings, several are native species already known to have high erosion-resisting values and are being used extensively by our Service. A number of these, normally collected from natural stands, have been found to produce an unusually good seed crop when grown under cultivation. Special attention is being given to species difficult and expensive to collect.

Further careful study of comparative costs of obtaining seed of important native species from natural stands as compared with their seed production under cultivation may prove to be important factors in shaping future policy.

The advantages of growing seed of native grasses under cultivation depend primarily on the following: Certainty of a seed crop; higher yield per unit area; freedom from mixture; improved quality of seed; decreased unit cost of seed; and stimulation of seed production as a new farm enterprise.

The uncertainty of a satisfactory seed crop from natural stands, as well as the scattered distribution of

(*Continued on p. 84*)

*Threshing **Eragrostis curvula**, Tucson nursery. Yield of 300 pounds cleaned seed per acre. Two crops of seed were obtained this summer. One of the important introduced grasses which have passed through observational stage and are now in quantity production for project use.*

[1] Head, Grass Unit, Section of Conservation Nurseries, Soil Conservation Service, Washington, D. C.

WILDLIFE MANAGEMENT

William R. Van Dersal[1]
Writes about

Soil-saving plants that provide feed and cover for birds and mammals

THE soil conservation program at the outset included the development of the wildlife resource, wherever possible turning erosion-control operations to the advantage of wild mammals and birds.

Pioneering Plants

On demonstration projects and camp areas the use of pioneering vegetation in critically eroded or eroding areas had as a secondary result the production of adequate food and cover for wildlife. Fortunately, those plants that have demonstrated their ability to lead the way in the colonization and reclamation of eroded land are often among the best species for wildlife. They may be expected, because of their ability to initiate secondary plant successions, to thrive on the poorest sites and with their protecting cover to prevent soil washing. At the same time, if proper selection of plants has been made, they will offer the maximum of food and cover for wildlife at critical seasons of the year.

No experiment station nor plant testing station is needed to discover these pioneer species. They can be found in any gully or on any eroded land, appearing naturally, as the long process of reclothing the land is undertaken by Nature herself. The whole country, in fact, may be considered a testing ground wherein species of plants have for thousands of years succeeded or failed. The operation of natural environmental factors has effectually prevented all species except those best adapted to grow on barren sites from appearing as pioneers. Observation in the field can now show us the successful species and from these we may select those of particular value in encouraging wildlife. Mention of only a few outstanding types among the hundreds of pioneer species available for erosion control and wildlife plantings can be made.

Legumes and Grasses

Legumes rank among the best of pioneers. It is known, for instance, that the percentage of wild legumes in the native vegetation of impoverished soils is comparatively high, and that in natural revegetation, the percentage of legumes decreases with the increase of total nitrogen in the soil.[2] Their invaluable aid in improving soils is of the first importance to agriculture, not only in the usual crop rotation and green manure production, but in eroded soil reclamation as well. A fact not generally recognized is that from East to West legumes are of great importance to quail. The California quail gets more than 32 percent of its total food supply from legumes;[3] nearly 39 percent of the food supply of the southwestern Gambel quail consists of legumes;[4] and over 20 percent of the average monthly diet of the eastern bobwhite is composed of legumes.[5] It is obvious, therefore, that wherever it is practicable to use legumes in a properly planned erosion-control program, quail at least will be well supplied with food.

Grasses of many kinds, more notably those producing a lush growth, are much used by ground-nesting birds. Where proper selection of pioneer forms is made, establishment of thick grass cover on eroded areas can assist materially, often better than other kinds of vegetation, in conserving soil. Mixtures of grasses and legumes have proved of particular worth in erosion control and wildlife conservation in the Southeast.[6] The leaves of both grasses and legumes, as well as the seeds, are freely consumed by birds and mammals.

Woody Plants

Among woody plants certain genera appear of outstanding value. All species of *Symphoricarpos* (snowberry, coralberry) are pioneers, and 33 species of birds are known to eat the fruit. Coralberry (*S. orbiculatus*) has been used with considerable success for living check dams. The genus *Rhus* (sumacs) contains 20 species, most of which are pioneers. Nearly 100 species of birds and many mammals feed on sumac berries. The species of blackberries of great importance as pioneers on barren or eroded land are eaten by 146 kinds of birds as well as over 25 kinds of mammals. Sassafras, smilax, and vitis (grapes), in addition to furnishing pioneer species, have berries eaten by 18, 43, and 87 species of birds, respectively.

(Continued on p. 75)

[1] Biologist, Section of Wildlife Management, Soil Conservation Service, Washington, D. C.

[2] Campbell, E., 1927. Wild Legumes and Soil Fertility. Ecology, 8:480–483.

[3] Sumner, E. L., 1936. A Life History Study of the California Quail, with Recommendations for Conservation and Management. Calif. Fish and Game 21:177.

[4] Gorsuch, D. M., 1934. Life History of the Gambel Quail in Arizona. Univ. Ariz. Biol. Sci. Bull. 2:30.

[5] Stoddard, H. L., 1932. The Bobwhite Quail, Its Habits, Preservation, and Increase. 559 pp., illus. New York, p. 135.

[6] Stevens, R. O., 1937. Handbook of Wildlife Management. Region 2. 31 pp. mimeo.), illus., Spartanburg, S. C., March. p. 19.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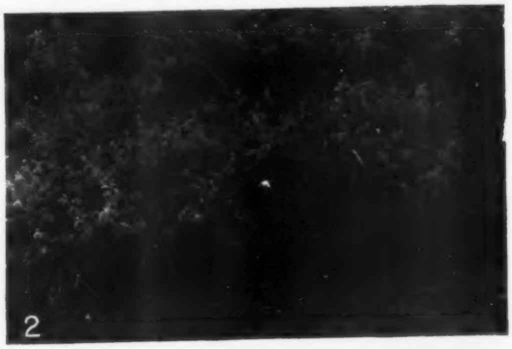
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The grapes, particularly, are utilized by a great many species of mammals.

The junipers are of outstanding value for wildlife not only as food but because they provide evergreen cover. The berries of the 16 native species are eaten by 50 kinds of birds and most noncarnivorous mammals. Unfortunately, the fact that the species grow very slowly, makes their use in an erosion-control program of less value than if they were rapid-growing. In conjunction with low-growing cover crops, however, and because of their ability to succeed on extremely severe sites, they have a very definite place in any program of wildlife management that also conserves soil.

The genus *Prunus*, containing some 44 wild species of plums and cherries, is superlatively attractive to numerous birds and mammals. One or another of the species pioneers in nearly every part of the country. They are being widely used, precaution being taken wherever necessary to prevent stock-poisoning by certain cherries. Wild plum (*P. americana*, *P. angustifolia*) seems to be of noteworthy value.

Ceanothus (Jersey tea, buckbrush) and *Arctostaphylos* (bearberry, manzanita) provide many pioneer and wildlife-encouraging forms. Species of the first genus possess nitrogen-fixing nodules and hence, like the legumes, assist in soil improvement. Others that find a use on various eroded sites being planted for wildlife could be mentioned, such as certain oaks, persimmon, buffaloberry, shrubby dogwoods, huckleberries, hawthorns, crabapples, chokeberries, and the introduced Russian olive.

Within a broad program of soil conservation the establishment on severely eroded sites of vegetation that is useful in the production of a wildlife crop is practicable and easy of accomplishment if intelligent selection of species and planning precedes operation.

THE PICTURES

Sumacs of west (1) and east (7) bear fruit attractive to wildlife and produce good cover on eroded lands. They are of great value to the cottontail rabbit.

The native Lespedeza procumbens *(2), occurring naturally on eroded soil, is a legume valuable to the bobwhite for seeds and greens. Note the accumulated litter below the early spring growth.*

Persimmons (3) are useful for erosion control and wildlife; the fruit is eaten by many birds and mammals.

Wild cherry (4), good for soil and wildlife conservation in ungrazed areas. Cattle are sometimes poisoned, however, by browsing on the leaves.

Russian olive (5), an introduced plant useful for food and cover in wildlife plantings for erosion control.

Callicarpa americana *(6), used in the Southeast in wildlife plantings. Valuable for food and browse.*

Among shrubs, wild raspberries (8) are noted for their ability to grow on eroded soils and provide both food and cover for wildlife.

A Promising New Cedar for Erosion Control[1]

By Charles F. Swingle [2]

THE large-scale work in erosion control now under way has served to arouse interest in *Juniperus ashei*, the Ozark white cedar. Throughout much of the United States demands are insistent for extensive amounts of red cedar for planting on exposed areas where few other plants can survive. Due to the prevalence of the cedar apple rust (*Gymnosporangium Juniperi-virginianae* Sch.) and the widespread occurrence of both native and cultivated apples which serve as alternate hosts for this rust, it has been necessary either to ignore the rust on the one hand, with consequent risk both to the cedar trees themselves and to apple orchards in the vicinity, or on the other to substitute some otherwise less desirable plant for the proved red cedar. What is distinctly needed in a large part of the United States is a tree of the character of *J. virginiana*, but one immune to cedar apple rust.

Identification

In 1930, Buchholz [3] called attention to a new species of juniper which he named *Juniperus ashei*. He emphasized that it was of the same general type as *J. monosperma* (Engelm.) Sarg. though sufficiently distinct to warrant specific rank, that its occurrence was limited to a small area along the White River in northwestern Arkansas and southwestern Missouri, wholly out of the range of any other juniper except *J. virginiana*, and that it was immune to the cedar apple rust.

[1] This paper reports some of the observations made by the writer and other members of the Soil Conservation Service, particularly William Giles, Roger Sherman, and D. H. Foster. Thanks are also due to several other individuals both within the Soil Conservation Service and in other agencies and especially to Dr. D. M. Moore, professor of botany, University of Arkansas, and Mr. J. C. Dunegan, of the University of Arkansas and the Bureau of Plant Industry.

[2] Horticulturist, Section of Conservation Nurseries, Soil Conservation Service, Washington, D. C.

[3] Buchholz, John T. The Ozark White Cedar, Bot. Gaz., 90: 326–332.

Two points concerning the classification of the Ozark cedar can be stated rather definitely; first, it is unquestionably distinct from *J. virginiana*, the only other juniper of the region, and second, its nearest relatives are found hundreds of miles away from its limited range.

It is not entirely settled just what relationship *J. ashei* bears to *J. monosperma* and to *J. mexicana* Spreng. In his original description, Buchholz ignored *J. mexicana*, confining his comparisons to the similar *J. monosperma* and the distinct *J. virginiana*. The United States National Herbarium has no specimens of *J. mexicana* from the United States. The various specimens from Mexico show differences from *J. ashei*, particularly in size of seed.

Mattoon, Phillips, and Gibbs [4] showed *J. ashei* as occurring in Oklahoma. This is not an extension of the Ozark juniper across the line into northeastern Oklahoma, but refers to material from southwestern Oklahoma, doubtless much closer to the type of *J. mexicana* than is the Ozark material. In 1936, however, members of the Soil Conservation Service while scouting for other plant materials found this species in Mayes County, Okla. This is undoubtedly an extension of the previously known range of the Ozark form.

Palmer and Steyermark [5] are inclined toward accepting *J. mexicana* as the approved name for the Ozark cedar, though apparently with the idea that the individuals occurring in the Ozark region constitute a rather distinct geographic type. As emphasized by Buchholz, the Ozark cedar is wholly distinct in form from Eastern red cedar. The Ozark cedar usually branches at or near the base while the red cedar is almost invariably single-stemmed. The Ozark cedar (in common with *J. mexicana* and *J. monosperma*) displays under a magnification of $\times 20$ or greater, some 30 to 50 or more fine serrations on each edge of each leaf, while the red cedar has entire leaves. Red cedar, as its name implies, shows more or less lively red in the heart wood, while in the Ozark cedar the heart wood is yellow or brown—never red. The Ozark cedar has the stiffer branchlets and when its leaves are crushed they emit a distinctly turpentiny and to most people much more pleasant odor than that which characterizes the red cedar leaves. When in fruit the Ozark cedar is readily and clearly distinguished from red cedar, the fruits of the former being in general about twice the size of the latter even though some 95 percent are one-seeded. The Ozark cedar fruits are much fleshier than those of red cedar and yield only about one-seventh of their total weight in clean seeds, as opposed to approximately one-fourth for red cedar.

Although the Ozark cedar occurs along the White River for some 150 miles, and is not at all rare in this region, probably throughout its limited range it is outnumbered 10 or more to 1 by the common red cedar. One of the sites with the largest individuals and the thickest stands is on the east bluffs of the North Fork of the White River, near Henderson, Ark. Many individuals here are 20 feet in height. Throughout the region of its occurrence it is variously referred to as white, yellow, or "Molly hairy" cedar.

Resistance to Gymnosporangium Rusts

An outstanding characteristic is the entire absence of any cedar apple rust galls such as are usually abundant on red cedar trees throughout the Ozarks.

Buchholz stated that the Ozark cedar was immune to cedar apple rust. His basis for this statement was apparently wholly that of field observation. The present status of the question remains about the same—apparently no one has ever observed a single infection on this cedar growing under conditions which make for serious infection of the red cedar. Whatever the outcome of any future inoculation experiments, it seems proved that the Ozark cedar must have a very high degree of resistance to the type of Gymnosporangium so prevalent in the Ozark region. It is interesting to speculate as to just how much this immunity is based on its characteristic turpentiny oils.

How this cedar will react under other environments is yet to be proved. By analogy, however, considering the general uniformity with which red cedar is attacked

[4] Mattoon, W. R., G. R. Phillips, and F. J. Gibbs, Forest Trees of Oklahoma, Oklahoma City, 1932.

[5] Palmer, E. G., and J. A. Steyermark, Plants of Missouri, Annals Missouri Bot. Gard. vol. 22, September 1935.

An example of the female tree as it occurs north of Lead Hill, Ark., near the Missouri line.

by the rust throughout its entire range, it does not seem too optimistic to expect that the Ozark cedar will prove, from the practical standpoint at least, to be completely immune to the cedar apple rust. This hope seems justifiable when one considers how its nearest relatives react. Arthur's Manual [6] lists three Gymnosporangium rusts which have been reported for *J. monosperma*, and one for *J. mexicana*. Of the former, neither *G. speciosum* Peck, nor *G. multiforum* Kern attack any members of the Rosaceae as alternate hosts. *G. nelsoni* Arth. apparently use various members of the Rosaceae as alternate hosts with juniper, but have never been reported on apple either wild or cultivated. *G. exiguum* Kern, the only rust reported for *J. mexicana*, affects Crataegus but apparently no other members of the Rosaceae. Hence apparently both *J. mexicana* and *J. monosperma* are free from all serious rust damage involving apples, and the hope that the Ozark cedar will continue to prove immune to the cedar apple rust seems to be well grounded.

Conservation Values

As suggested above, there is an insistent demand for a rust-free tree able to stand the extreme conditions of drought, heat, and cold which red cedar is so well able to combat. How does the Ozark cedar compare in this respect? As illustrated, it occurs naturally in some of the most extreme rocky ridges of the Ozarks. In very few places does it occur at all where there is enough soil for deciduous trees to gain a foothold. Uusally the Ozark cedar occurs with the red cedar at the crest of the hill, but the Ozark cedar does not follow the other as it moves down into the hardwood zone. The Ozark cedar is confined to the dolomitic and calcareous outcrops and bluffs in the western part of its range and to the sandstone outcrops and bluffs in the East.

Though it seems to occur naturally only on extreme rocky situations this is not because growth is impossible on better soils. Along with a number of others, the specimen shown was dug in the wild as a small seedling and planted on the university campus at Fayetteville 9 years ago. No exact measurements have been kept, but apparently the rate of growth of the Ozark cedars has been comparable to red cedars handled similarly at Fayetteville.

It seems obvious that the Ozark cedar is able to withstand heat, drought, and poor soil just as well as does red cedar, though the limited range of the former would lead one to suspect that it might be the more critical of soil conditions, especially with regard to demanding a relatively high alkalinity.

A transplanted specimen of **Juniperus ashei** *on the campus of the University of Arkansas, Fayetteville*

As to cold resistance, about all that can be said now is that temperatures of $-20°$ F. are not unknown where it occurs and that there are no evidences that winter injury has played any part in its sharply delimited range. Furthermore, 1-year seedlings in the nursery at Elsberry, Mo., went through the winter of 1936–37 with no indication of winter injury. In the spring of 1937 some of these seedling were sent to Soil Conservation nurseries in North Dakota, Washington, California, New Mexico, Colorado, North Carolina, and Ohio, and to Bureau of Plant Industry stations in Maryland and Wyoming, and it is hoped to have readings on hardiness in those States starting with the winter of 1937–38.

The two preceding paragraphs partially answer the questions regarding the value of this species in erosion

[6] Arthur, J. C. Manual of the Rusts in the United States and Canada. 1934.

work, for the ability of any species merely to live under the conditions where it grows is sufficient to insure its having some place in any large-scale erosion program.

Wood Qualities and Uses

The Ozark cedar, however, will do much more than merely live under extreme conditions. In the immediate area of its occurrence its wood is considered as valuable as, if not a trifle more so than that of red cedar. For example, Will Sharpe of Flippin, Ark., post buyer for the A. L. Budd Hardwood Company, handlers of large quantities of cedar posts, stated that he considers the Ozark white cedar a little better than the red cedar because its wood is harder and holds staples much better. Mr. Sharpe emphasized that the lasting quality of cedar posts is due almost wholly to the proportion of heartwood to sapwood, the color of the heartwood making little if any difference. The writer inquired at several places just outside the area where the Ozark cedar occurs and was told, "Yes, we have white cedar here, but it isn't nearly so good for posts as red cedar." On closer examination, however, it seemed that what was looked on as white cedar was really young *J. virginiana* with a high proportion of sapwood. Apparently the Ozark cedar is as variable as the red cedar in this matter of relative proportions of heartwood and sapwood.

Obviously the tendency of the Ozark cedar to branch close to the ground makes it not quite so desirable for post production as the erect-growing red cedar. In spite of its globular form, however, the Ozark cedar shows generally straight growth and ultimately each of the several framework branches makes a usable post. Certainly with a very slight amount of attention in the matter of pruning, it could be made to show a post yield per acre comparable to that of red cedar.

This branching tendency, as well as the somber color of the wood, definitely indicates that the Ozark cedar can hardly be expected to have much value as saw lumber.

Wildlife Value

Its spreading habit should contribute toward making the Ozark cedar a very desirable species for ground cover.

Furthermore its large fleshy fruits seem to be of considerably greater value as game food than the smaller and drier fruits of red cedar. This was especially emphasized in January 1937, when a large crop of Ozark cedar fruits completely disappeared within a few days following a heavy snow which put a premium on other bird food. The robins seem to be particularly fond of these fruits.

Natural reproduction is wholly by seeds. The exact conditions required for germination are not at all known at the present time. Seed of the 1934 crop harvested in the winter, allowed to dry and planted in April 1935 at the Elsberry, Mo., nursery of the Service, failed to germinate until the spring of 1936, when a very satisfactory stand was obtained.

There was no seed crop available for collection in the fall of 1935.

Seed of the 1936 crop, harvested in the winter and planted within a few days after the seed had been cleaned from the flesh, gave prompt germination in April 1937 at Manhattan, Kans., and elsewhere.

These somewhat divergent results are not at all surprising in view of similar erratic behavior frequently experienced with other junipers. In this connection it will be remembered that with reference to other junipers, Peck[7] found that the seed should be subjected for 100 days to a temperature of approximately 41° F. for after-ripening and germination. Following germination a temperature of approximately 60° F. seemed indicated.

Seeds of the Ozark cedar appear to be fully mature about the middle of November, after which time they can be readily shaken from the tree. Many of the fruits are found to have sterile seeds—some plants showing only 20 percent or even less plump seeds. It is interesting to note that under the same conditions red cedars show many worthless seeds.

Many tests made at the Elsberry nursery in the fall of 1935 indicated that even with bottom heat it is not easy to root cuttings of the species.

There seems to be no opportunity for any large-scale collection of wild seedlings, since they occur on such rocky sites and are always mixed with red cedar.

Summary

The Ozark white cedar seems promising for planting on extremely dry or rocky sites such as those where the eastern red cedar is indicated. It seems especially adapted to limestone soils. It has durable wood, furnishes good post material, is a highly-prized wildlife species and is apparently immune to the cedar apple rust.

The dollars-and-cents value of vegetative cover is clearly set forth in two articles soon to appear in SOIL CONSERVATION, in which are reviewed some recent experiences with debris basins.

[7] Peck, Dean A. After Ripening and Germination of Juniperus Seeds. Bot. Gaz. 71: 32-60. 1921.

NEW LIFE FOR THE OLD FARM

by **Walter V. Kell**[1]

This is the story of an eastern corn belt farm during the years from 1933 to 1937.

THE owner of the farm (he was called "Dad" by all who knew him) was beginning to show the results of long years of toil devoted to carving out his acres from the virgin wilderness. In fact, two farms had been subdued by him and left as monuments to his ceaseless toil. It had been no small task—the clearing of forests, breaking the stubborn, tough prairie sod for more corn, more potatoes, vegetables and wheat to feed the large family. Now there were no new farms to be put under the plow, and hard work and long hours were what it took to make a bare living off the old farm. Dad was getting tired. He spent a great deal of time in talking about the accomplishments of the past and in encouraging the boys to go ahead with the work which he had started when the country was new.

Thrift had been almost a religion with Dad. More-corn-to-feed-more-hogs-to-buy-more-land had been his theory. He had argued that each new acre put under the plow made the farm that much more valuable, and he could not understand that his theories did not appeal to the boys who were sizing up the old farm and secretly comparing the possibilities with those in neighboring fields where the pastures were greener.

To the boys it seemed that so many crops had been extracted from the old farm that very little was left of it. Certainly it would take more than long hours and hard work to obtain from those badly leached and faded acres anything remotely resembling the bounteous crops of the past. They were loyal, however, and they did not want to give up. They had heard of new farming methods, much talked about but not practiced by many farmers. Had Dad known about these methods and used them in the early days—but he hadn't, and now, looking over their bleached acres, the boys were skeptical. What could be done with such land? In spite of their skepticism they felt a keen interest in the new ideas and a strong desire to try them out on the old farm.

But the farm would no longer support the large family and two of the boys left. Fortunately they found jobs with the C. C. C. They all hoped that some outside money might keep the old home farm going for a few more years. The boys who stayed with the land worked harder than ever before to make up for the labor that had gone to the camp. There was no time now for the new ideas; every hour and every square foot of ground must be worked to produce the necessities of life.

But it was not long before a letter arrived from the boys in the camp, telling about their new jobs with the Government. The work was right down their alley. The Government had started a new program to prevent soil erosion. Soil erosion was responsible for the abandonment of many farms and, incidentally, for the low yields on the home farm. Their camp was assigned to this new soil-erosion control work, and although they did not as yet know much about the program, they thought it would be a good idea to do a a little experimenting on the old farm and, if the plan worked out, it could be used to advantage in encouraging neighboring farmers to join them in the experiments.

The two brothers who were at the camp wrote out some definite suggestions, the first having to do with a rearrangement of cropping plans into an improved rotation. Just why this was necessary they did not know; but they had noticed that cultivated crops such as corn or potatoes seemed to thrive more and show a darker green color following a hay crop, especially if the hay crop happened to be clover or some other legume, than when repeated year after year on the same ground. They recalled, too, that the last small patch of new ground on the old home farm did not wash as badly after plowing as other fields which had been in use for many years.

The boys on the farm were interested. They began observing the effects of different crops. They discovered that when sod ground was plowed it washed very little during the first year or two. They decided to find out the reason for this. They made inquiries here and there and learned that at Ithaca, N. Y., a soil-erosion experiment station had been established and that some of the experimental plats had been laid out on new ground—land freshly cleared from the forest.

After casting lots one of the boys made the trip to Ithaca to see the experiments. He learned that from the new land there was almost no loss of either rain or soil—and this regardless of the farming method used and even on rather steep slopes. Across the fence were contrasting plats, laid out on land that had been

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farmed for a number of years. There a great deal of rainfall was lost as run-off, and it carried with it large amounts of topsoil unless some obstruction, such as terracing or vegetation, was present to strain out the soil and hold it on the hillside. The boy from the old farm had learned a valuable lesson. He could understand now why Dad had not been interested in the new farming methods. Dad had begun farming with new land; he had developed his thoughts and his habits in terms of farming new land and, before he realized that there was such a thing as soil erosion, most of the topsoil had been washed from the slope down into the creek that drained the farm. The boy went home to describe what he had seen at the soil erosion experimental station.

The question was, What can we do to this land to restore its vitality, to prevent further serious erosion? And they went out to make a few investigations of their own. They found that on the newer land decaying plant roots were mixed through the soil and that its mechnical and physical condition was good. This soil had been the home of millions of earthworms and other living organisms. It had been protected by vegetation which had kept it alive and active throughout the long years. In other words, this new soil had life while the soil on the older fields seemed dead.

The boys recalled that throughout the long years the old fields of their farm had been planted to corn in the spring and cultivated all summer. The corn was harvested in the fall, and the soil lay bare until the next summer when another crop was planted. They knew now that if this continued it would not be long before the very life of the land would be irrevocably destroyed. They determined to correct some of the errors of the past.

The young farmers heard of an acreage down in Georgia, operated by R. L. Hardy, where some of these difficult problems had been solved. For the second time they cast lots and one of the brothers made the trip to visit Mr. Hardy, who lived near Senoia, and to walk over his entire farm with him. He found that Mr. Hardy was growing a mixture of crimson clover and rye grass which occupied the ground continuously except during the comparatively short season required for a corn or cotton crop. And, what was stranger still, not even during the crop season was all the field plowed for corn or cotton; for Mr. Hardy had learned that by leaving a small strip of unplowed land between each row (he called it the "balk system") his crimson clover and rye grass matured seed before it was time to do very much cultivating in his short-season crop.

As soon as this seed was mature, Mr. Hardy explained, it would be covered rather deeply with the cultivator. It would then lie dormant until the end of the cultivating season when he would again work it up to the surface and allow it to start growth with the first late summer or early fall rains.

This cover crop, as Mr. Hardy called it, would not do much in the way of growth until the corn or cotton was almost mature. Then, as more sunlight reached the ground, the crimson clover and rye grass would take possession, covering every square inch of the soil until rows were again plowed for the next year's cash crop. Mr. Hardy had stands of crimson clover and rye grass that had been seeded 5, 6, and 7 years before, with no new seed being applied. All farming operations under Mr. Hardy's system were strictly on the contour. With the combination of dense growing vegetation and contour farming practices, rain water loss was minimized or eliminated and there was no sign of erosion on any of his fields. A portion of the crimson clover and rye grass was permitted to mature a seed crop for harvesting, in order that, should unusual weather conditions cause a failure of voluntary seeding, new seed would be at hand for the continuance of the system. There was always a good stock of seed on hand.

The young farmer went home to the old farm determined to imitate Mr. Hardy's practices. The brothers, once again viewing their bleached acres, discussed eagerly the problem of a cover crop; for they were convinced now, beyond all questioning, that it was necessary to keep the soil protected at all times when not engaged in producing clean-cultivated crops for harvesting. They were not sure that crimson clover and rye grass was the cover crop suitable to their land and climatic conditions. Another crop should be substituted. Rye, they decided, would be satisfactory, since it could be seeded over rather a wide range of dates even though the soil was fairly dry. Growth would start when the rains came. In favorable seasons rye would provide some pasture both in the fall and the spring, and, most important of all, rye would provide protection to their soils during those long months which previously had been so damaging.

Time passed and the old fields knew the comfort of protective cover. The young farmers soon discovered that by turning under a good cover crop the clean-cultivated crops responded more nearly as they would on new soils. They discovered also that soil wash was lessened. Another year passed, and a large field which had been protected by a cover crop over the winter,

"The plants were badly battered, many of them entirely washed out."

was plowed and planted to corn, the contour method being employed throughout all operations. The young farmers on the old farm were now using rotations, cover crops, and contour tillage—certainly, these practices would go a long way toward providing the big yields they hoped for.

The corn grew and was a beautiful sight with its long curving rows and its new plants evenly spaced over the entire field. They finished the first cultivation. It was about the middle of June. In the night a storm of cloudburst intensity broke, and rain pounded the roofs of the farmhouse. Several inches of rain fell within a few hours. The boys could not but wonder what was happening in their cornfield.

Early the next morning they started out. The hay field was bright and green with no damage whatsoever from the enormous amount of water that had fallen in so brief a time. They crossed the pasture where there was still enough water to ooze up around their shoe soles at each step, but the grass was in excellent condition. They were certain now that they would be provided with good pasture for a long time to come. The rain water was retained on the ground by the grass, it would sink into the soil gradually, be pumped out again as the grass needed it. The pasture soil was protected from washing.

The next field was the corn field. Here their hearts sank, for the plants were badly battered, many of them entirely washed out, and all depressions and low areas in the field were either washed to the gully stage or filled with water that would surely drown the corn. This was a serious blow. It was too late in the season for a second planting, and so much had depended on that year's crop.

The boys spent the morning lamenting the loss of their corn crop and the damage to that important field. To fill the gullies and level the field—the extra labor would mean a real expenditure to them. They could not afford it.

Soon another letter came from the C. C. C. workers. It told of producing crops in strips, to provide protection at all times for the clean-cultivated areas.

Why hadn't they thought of this before! There was the hay field which had received the 4-inch rain without even slight damage. Had they distributed the hay in strips, alternately, through the corn field, they could have saved not only the corn crop but the field as well. This would not happen again.

It required 3 years to establish the contour strips properly, with sufficient dense vegetation in the control strips to provide the necessary protection. As an extra precaution, a diversion ditch was constructed across the slope above the strips to intercept surplus water from the drainage area above and empty it on the pasture where it could do no damage. In fact, the grass needed much more water through the summer months than was formerly available.

Later, the pasture itself presented a problem. In long dry periods the grass and soil became very dry so that when sudden heavy rains came the water ran off as from a pavement. A letter was sent posthaste to the camp boys. How can we hold the heavy summer rains on the pasture field? Soon there was the answer—contour furrows. Small contour furrows, spaced about every 4 feet, would do the trick. The water from those sudden heavy downpours couldn't go far without being trapped and held in the contour furrows. The soil, once moist, would absorb all the rain.

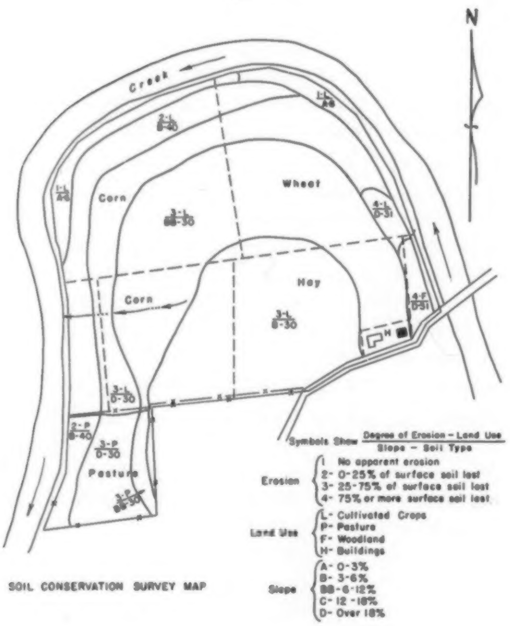
"The old farm was a good farm, after all."

The young farmers now could visualize a transformed farm with improved crops and pasture. Now they could afford to use fertilizers and to plow under a green manure crop occasionally and now not all their acreage was required for growing corn and potatoes. The acre yields were higher, and less acres meant more leisure. The old farm was a good farm, after all. It was a slow process, but the new ideas were producing results. *(Continued on p. 84)*

FARM PLANNING

Vegetative cover is a controlling factor, *says* H·C·Diener[1]

Figure 1.



SOIL CONSERVATION SURVEY MAP

THE Service has planned over 50,000 farms. The primary objectives are the control of soil erosion by wind and water, and moisture conservation. In planning a complete reorganization of the farm for soil and moisture conservation, the economics of a well-balanced farm program must have consideration at all times.

In planning the farm, the conservationist has a number of points to bear in mind, which may be divided into two general classes: (1) physical characteristics of the land and (2) economic influences. Some of the physical points are steepness of slopes, degree of erosion, erodibility of the soil, and vegetative cover. Among the economic factors influencing the plan are livestock units, feed requirements, efficient crop use, marketability of crops, land value in comparison with structural costs of control measures, and permanency of measures recommended.

The success of the plan in operation rests on the practicability and crop balance in the agronomic program, the efficient use and management of forest land, and the economy of the farm reorganization. The farm must be the unit for the plan and not particular fields as individual areas. Costs must be defrayed from the productiveness of the whole farm, according to the best land use decided upon by agronomists, foresters, engineers, and conservationists in accordance with the type of agriculture best adapted to that region.

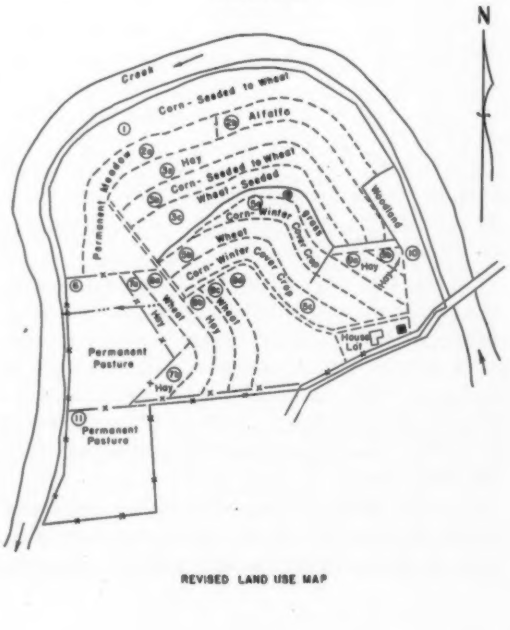
In many instances it may be desirable to make more radical changes in the methods of farming rather than the type of farming, especially in the older areas of the country where systems have been developed by long years of experience.

Representative Farms

Figure 1 represents a typical Pennsylvania farm of the general-purpose type, where almost one-half of the acreage has been devoted to the growing of clean-cultivated crops each year. A rotation of corn-corn-wheat-hay occupies four fields, selected for their similarity in size rather than in recognition of soil, slope, and the possibility of severe erosion.

Past practices have set up a square system of farming on curves and slopes of this farm, and erosion has taken its toll during the past years, as is evidenced by the physical land survey. The flat bottom land along the

Figure 2.



REVISED LAND USE MAP

[1] In Charge, Erosion-Control Practices, Soil Conservation Service, Williamsport, Pa.

creek shows very little erosion, but with increasing steepness of the slope there is more and more evidence that in a very few years, under present practices, a large area of this farm will have none of the topsoil remaining.

Technicians of the Soil Conservation Service, in planning a reorganization of this farm, as shown in figure 2, have kept in mind a yearly balance of crop needs, permanent vegetation on the steeper slopes, contour strip cropping on the lesser slopes, close growing cover crops on clean-cultivated areas during critical periods of erosion, and diversion of excess water on long slopes where vegetative cover was considered insufficient to control rapid run-off and erosional drainage.

The critical areas found in fields 2a and 2b, with slopes of 12 to 18 percent showing severe sheet erosion and some gullying when used for clean-cultivated crops, were removed from the regular rotation and put in permanent sod cover. Field 6 on a slope above 18 percent was retired to permanent pasture with fertility treatment to induce growth of a good vegetative cover. Field 11 on a similar slope, with more than 75 percent of the topsoil removed, was retired to forest, to give protection from erosion, increase woodland products on the farm, and afford wildlife cover.

The remaining portion of the farm was laid out in contour strips, and a rotation was established to alternate a grass or close-growing grain crop with clean-cultivated crops.

First-year cultivated crops on fields 3a and 5c are followed by winter cover crops, and this practice will be adopted in future years on all areas having clean-cultivated crops.

At a point on the slope where run-off might cause erosion damage during the rotation, a water-intercepting channel was placed to carry this excess water gradually around the slope and down to lower levels through a vegetated outlet. A contour strip of permanent sod above the intercepting channel affords protection and filters silt from excess water originating on the upper slopes.

The reorganization of this farm has all fields on the contour of the land, and all farm operations follow level contours with economy in horsepower necessary to operate implements. The entire plan is one which might be placed in operation on thousands of farms throughout the country, with small additional costs above ordinary good farm practices. The program is based on sound economy and soil preservation for permanent agriculture.

Slope Usage

(*Continued from p. 67*)

income from wood and from home industries based on wood.

There are several trees now planted only for shade and street use that offer opportunities as high-priced specialty woods. The Empress tree, *Paulownia tomentosa*, grows rapidly and has good possibilities for figured veneer, furniture wood, and wood for many specialities, such as jewel caskets, waste-paper containers, and magazine racks. The Cedrela, or Chinese mahogany, and the Ginkgo offer other opportunities.

It requires little imagination to see that if man can live well on the very few plants he has sought to improve, then he surely can live better if he will seriously consider the possibilities in the tremendous number of unused plants at hand for similar improvement. Sufficient numbers of better than ordinary strains of trees, shrubs, and other long-lived crop plants are already available to start testing the hill-culture system of erosion-control farm management. But the real possibilities lie in directing research efforts toward finding and developing the many unexplored sources for better erosion-control plants and their improved uses for combined erosion-control and economic purposes. To this end, hill-culture research in the Soil Conservation Service works in full cooperation with the Bureau of Plant Industry and other plant research organizations of the Department, and with the State agricultural experiment stations, on selecting, testing, and improvement of hill-culture plants, products, and methods.

One of our plant-research cooperators recently remarked that when people hear about better grapes they immediately want them in hand for eating. It must be realized that overnight results are not to be expected of all that is attempted. Superior nut and fruit plants developed and tested by plant specialists are now available to landowners and control technicians at commercial nurseries, but the high cost involved in producing grafted stock tends to prevent its extensive use. As cheaper methods of vegetatively propagating plants are developed, these better plants

(*Continued on p. 84*)

BOOK REVIEWS AND ABSTRACTS
By Phoebe O'Neall Faris

METHODS IN PLANT PHYSIOLOGY. By Dr. Walter E. Loomis and Dr. Charles A. Shull. New York and London. 1937.

Here is the newest laboratory manual and research handbook for the plant scientist. It is a large volume presenting in an organized single text the experimental approaches to plant physiology and the essential analytical techniques of routine investigations. Directions for laboratory experiments are accompanied by explanations of objectives underlying experimental operations, and each experiment is supplemented with a few highly pointed queries and citations to related literature.

Research methods in the physiology of the green plant are outlined and explained in minute detail, and tested laboratory experiments cover a wide range—from simple demonstrations for use in elementary classes in biology or botany to quantitative exercises requiring research technique and apparatus. Findings of leading English, American, and continental investigators are summarized making the volume of value to the student and worker in plant physiology, forestry, genetics, horticulture, and farm crops.

The two topics, growth and movement, are treated together for convenience—this because, in the words of the authors, "so many of the movements of plants are dependent upon changes in relative growth rates"; and such factors as food and water supply, light, temperature, oxygen, and auxins are treated by the experimental-query method. Fruiting and its effect upon growth is discussed under the chapter heading "Growth-Differentiation Balance and Growth Correlation." The authors have included throughout the laboratory series several experimental procedures not found in ordinary manuals. Of especial note are Heinicke's flowmeter method of gas analysis, the adaptation of Guthrie's color standard in Schertz's quantitative estimation of chlorophyll, and a unique technique for study of the "dark phase" reaction of photosynthesis. A generous list of micro-chemical tests on tissue sections is also given.

Part II of the large volume is devoted to general methods for routine chemical and physical experiments in plant physiology including a chapter on statistical methods by George W. Snedecor, and more than 30 ready reference tables of physical, chemical and mathematical constants commonly required for analytical work. Of particular note in this section of the book are the chemical procedures for ash, nitrogen, and lipid determinations. Useful techniques for quantitative studies of osmotic pressure, surface tension and specific conductivity are also given along with the principles involved in use of apparatus.

The plant scientist will recognize in this work a new departure in texts in that it combines within one volume a plant physiology laboratory manual, a quantitative physico-chemical analysis, a bio-statistical handbook and ready reference tables of physical constants for analytical procedures.

GRASS SEED

(*Continued from p. 72*)

the seed, in some instances, makes the task of collection from natural stands very difficult. The same facilities used for the production of seed of accessions from the observational nursery could be extended to the production of seed of native species that are now collected extensively from natural stands. It is believed that such a policy will do much to insure a dependable seed source and assist in stabilizing the grass program of the Service.

During the last two seasons the number of acres of nursery land devoted to the production of grass for seed increase purposes has been greatly enlarged. At present, regions 4, 6, 7, 8, 9, 10, and 11 are devoting certain of their nursery acreage to the production of grass seed, and the seed produced in this manner has relieved the nursery personnel from making such extensive quantity collections of seed from natural stands. Species of *Bouteloua, Andropogon, Buchloe, Panicum, Elymus, Bromus, Stipa* and *Agropyron* are being grown for increase purposes. Introductions of *Elymus, Hordeum, Agropyron* and *Eragrostis* are also being increased. A typical threshing scene of *Eragrostis curvula*, recently brought into cultivation and use for the first time in region 8, is shown.

A 15-acre planting of *Eragrostis curvula* on the nursery at Tucson, Ariz., gave a yield of 4,300 pounds of clean seed. This seed crop was mature about June 15. A second seed crop should mature in October if seasonal conditions are normal.

NEW LIFE FOR OLD FARM

(*Continued from p. 81*)

Dad isn't farming now, but he is looking on contentedly. The two camp boys are back home and together they have an option on an adjoining farm which they think will respond to the new ideas, provide profitable employment, and carry them nearer their goal. These boys are *farmers*.

SLOPE USAGE

(*Continued from p. 83*)

can be planted more extensively for erosion-control purposes. A still larger opportunity lies in new and highly specialized hill-culture plants developed through cooperative effort of all plant research agencies to effectuate the national erosion-control program. No plant miracles can be expected in such work; it calls for organized and well oriented research over a period of years.

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